FARM MACHINERY AND PROCESSES MANAGEMENT IN SUSTAINABLE AGRICULTURE

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5.1. PERFORMANCE OF A CHESTNUT VACUUM HARVESTER – FIRST RESULTS

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Keywords: mechanization, chestnut orchard, harvester work rate.

ABSTRACT

In Portuguese chestnut producing regions, harvest is mostly manually. Nowadays it's difficult to find available labour. Harvest mechanization is a solution if some difficulties of actual harvesting systems, are solved. Currently the equipment available is not completely suitable to work under high humidity conditions and high concentration of leaves and chestnut burrs, conditions that can jeopardize equipment performance. Another difficulty is pointed out by the agro-industry that complains that chestnut mechanically harvested appear with stone, branches and other materials that depreciate their value. It is important to improve harvesting procedures. Equipment performance knowledge is an important step to find solutions for problems mentioned. In 2018 harvesting season, field trials took place in a chestnut orchard in Northeast of Portugal to get information of equipment performance. This paper presents work rate preliminary results of one vacuum harvester.

INTRODUCTION

In Portuguese chestnut (*Castanea sativa*) producing regions, harvest is mostly manually, collecting from the soil previously fallen chestnuts.

In the last decades chestnut harvesting machines are available in the market, in continuous technological evolution. The use of this equipment has reduced the harvesting time and the associated costs. It is also an answer to the lack of labour required for manual harvesting. Consequently it has been an alternative to traditional manual harvesting (Monarca, D. *et al.,* 2014a).

There are two main categories of chestnut harvesting machines: vacuum-type harvesters and mechanical pickers (Monarca, D. *et al.,* 2014a). These two types of equipment are commercially available trailed, mounted and self-propelled.It is expected that mechanical harvesting provides an improved quality of chestnuts, because a better work rate can reduce the time in which the fruits stay on the ground. The chestnuts must not remain too long in contact with the ground to prevent its desiccation, contamination by fungi and the risk that they might be attacked by rodents.However, for farmers fully enjoy these advantages, some aspects of the operation need to be improved: to reduce fruits damages caused by equipment and to improve equipment performance under high humidity conditions common during harvesting season.Chestnuts harvested with the equipment currently available in the market may not have better quality than the fruits manually harvested. In addition to the chestnut, some stones, branches and other inert are harvested, that by abrasive effect, damage the integrity of the chestnut and depreciate its commercial value, especially for fresh consumption. The percentage of damaged fruit is higher when harvested mechanically than when harvested manually. The most common damage assessment refers to: petiole absence, superficial scratches, visible strokes and tears in the epidermis, and deep abrasions affecting a thicker layer of the epidermis (Monarca, D. *et al.,* 2003; Monarca, D. *et al.,* 2005; Monarca, D. *et al.,* 2014b).

It is important to improve harvesting procedures and to improve the quality of work done by machines. Equipment performance knowledge is an important step to find solutions for problems mentioned.

MATERIAL AND METHODS

Field trials sites

Field trials took place in November 2018 in Northeast Portugal (41º 39' 35''N 6º 50' 46''W - altitude 885 m) over an area of 4275 m^2 with a slight slope (up to 5%) in an orchard of "Judia" cultivar, 25 to 35 years old, tree spaced 9.5 m x 9.5 m (site 1) (Figure 1). In this site was collected data to evaluate equipment work rate and work speed.

Fig. 1. Site 1.

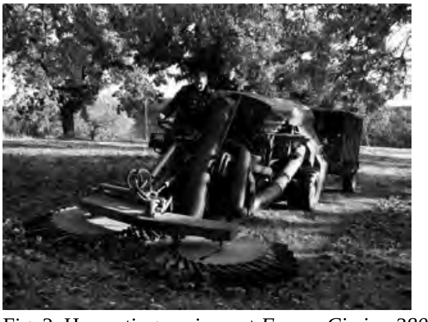

Fig. 2. Harvesting equipment *Facma Cimina 380*.

In a site 2, similar and near site 1, but with an area of 4250 m^2, was collected data to evaluate work speed.

Harvesting equipment used

A vacuum self-propelled harvester *Facma Cimina 380* was used (Figure 2). The characteristics of this equipment are in Table 1.

Table 1. Equipment characteristics.

Traction	Two rear-wheel drive with hydraulic transmission
Length (mm)	5950
Height (mm)	1890
Width (mm)	1770
Harvesting width (mm)	3000
Weight (kg)	2630
Power (kW)	74

The equipment has a centrifugal fan to produce the vacuum that picks up the material from the soil surface and is also used to separate the fruit from the burrs, leaves, small branches and others inert (Guyer, D. E. *et al.*, 2012).

Harvesting methods

The machine collected chestnuts from the soil in the area between rows traveling three times as shown in Figure 3. After the last of these three passes, the machine went to harvest in the next inter row area. Time for harvesting in each inter row includes time spent to turn over inside each inter row. There is a harvest interruption in the turns between inter rows.

Chestnuts collected are temporarily stored in a semi-trailer pulled by the harvesting equipment with a capacity of approximately 1000 kg.

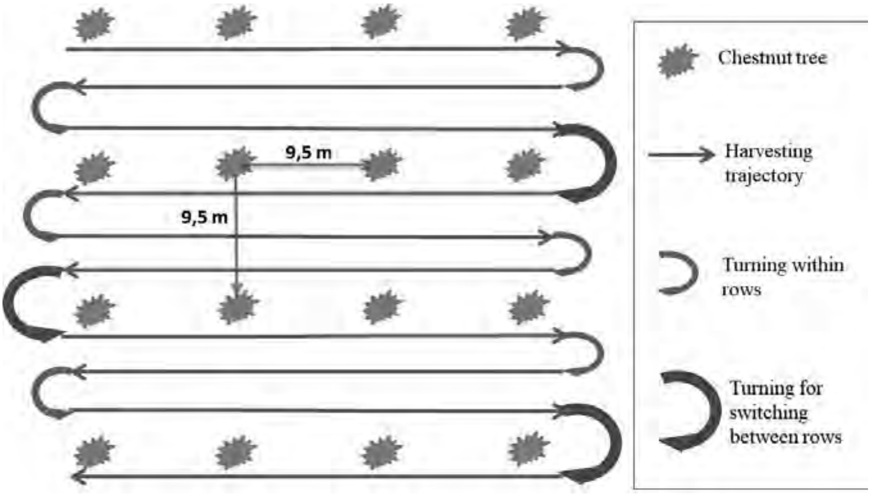

Fig. 3. Trajectories of harvesting equipment.

Work speed evaluation

The average work speed was evaluated by measuring with a chronometer the time spent by equipment between turns and relating this to the space travelled.

This data was obtained in two sites. Site 1 with three repetitions, and site 2 with four repetitions.

Equipment work rate evaluation

To evaluate the equipment work rate, time for each elementary operation was measured with a chronometer: harvesting time; inoperative time; turning time within two rows (during which harvesting continues) and turning time for switching between rows (during which harvesting stops). Inoperative time refers to the interruption of work to clear the product flow in the internal equipment parts.

Working rate was evaluated by the ratio worked area / time, in $m^2.s^{-1}$ and $ha.h^{-1}$

The total working time results by the sum of each elementary operation. Total harvesting time is obtained by adding harvest time to turning time within each row.

Total working time, because it includes turning times when harvesting is interrupted and inoperative time, is higher than harvesting time.

Harvesting performance is assessed by field efficiency: ratio between the sum of elementary operation time during harvesting and total working time. Field efficiency is expressed as a percentage, reporting the ratio of the time a machine is effectively operating, to the total time committed to the operation. (Hunt, D. 1983).

RESULTS AND DISCUSSION

Work speed

Average work speed: 0.96 km.h^{-1} to 1.47 km.h^{-1} or 0.27 m.s^{-1} to 0.41 m.s^{-1}.

Table 2. Work speed in site 1

Distance (m)	Time (minutes)	Medium work speed (km.h^{-1})
40	2.55	0.96
	2.73	
	2.25	

Table 3. Work speed in site 2

Distance (m)	Time (minutes)	Medium work speed (km.h^{-1})
169.5	6.31	1.47
	7.45	
	6.6	
	7.5	

Equipment work rate

Table 4 shows harvesting elementary operations time in field tests.

Table 4. Elementary operations time

Elementary operations (minutes)		Total elementary harvesting operations (minutes)	Total elementary non harvesting operations (minutes)
Harvesting	51.85	54.94	
Turning within two rows	3.09		
Inoperative	5.8		12.05
Turning for switching between rows	6.25		
Total		66.99	

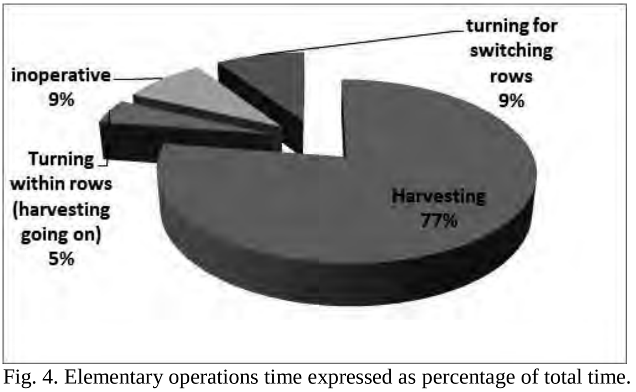

Fig. 4. Elementary operations time expressed as percentage of total time.

Considering 66.99 minutes to complete harvesting in 4275 m^2, results in these preliminary tests, a work rate of 0.383 ha.h^{-1} or 1.064 m^2.s^{-1}.

Field efficiency is 82%. This field efficiency value is satisfactory.
Inoperative time is 8.7% of the total. As observed in field tests, with higher humidity, and with many leaves on the soil, the equipment becomes less efficient or even inoperative as a result of obstruction / clogging of product flow inside equipment. In

these situations, not represented in this paper, a relative increase in inoperative time is expected.

The amount of chestnuts harvested was 700 kg (approximate value), resulting in 630 $kg.h^{-1}$, which is in accordance with references (Monarca, D. *et al.*, 2003; Monarca, D. *et al.*, 2005).

These are preliminary performance results. It is necessary to continue field tests with this equipment and others available in the market.

CONCLUSIONS

With manual harvesting it is expected to harvest 20 $kg.h^{-1}$ to 30 $kg.h^{-1}$ per person (Monarca D. *et al.*, 2003; Monarca D. *et al.*, 2014a). The results obtained in these preliminary tests point to a remarkable increase in the harvesting work rate with a vacuum harvester. This advantage makes it easier to match the time available to harvest preserving fruit best quality, with the area to be harvested. The reduction in the time necessary makes easier the double harvesting to reduce the period of fruit contact with the moist soil, with advantage for the chestnut sanitary conditions. Double harvesting means to harvest the same area twice. This procedure can be considered necessary because chestnuts are falling to the ground over a period of three or four weeks.

Results show an inoperative elementary operation of 8.7% of total time, necessary to clean the product flow inside of equipment. This slows down the work rate. To solve this problem it is important to improve the chestnut cleaning procedure inside the equipment.

Mechanical harvesting is also a solution to the labour shortage for this operation. In future work, fruit damage should be evaluated and harvesting costs evaluated.

Harvesting costs must be evaluated for a better understanding of mechanical harvesting advantages. Costs of manual and mechanical harvesting must be compared.

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REFERENCES

Guyer, D. E., De Kleine, M.E. and Perry, R.L. (2012). New approaches in cherry and chestnut harvest systems. *Acta Hortic. 965, 189-194 DOI:10.17660/ActaHortic.2012.965.25*

Hunt, Donnel (1983) Farm Power and Machinery Management. 8th edition, *Iowa State University Press, Ames.*

Monarca, D., Cecchini, M. and Antonelli, D. (2003). The influence of mechanical harvesting on the quality of chestnuts: experiences in the monti cimini area. *Acta Hortic. 599, 611-616. DOI: 10.17660/ActaHortic.2003.599.79*

Monarca, D., Cecchini, M., Antonelli, D., Mordacchini Alfani, M.L., Salcini, M.C. and Massantini, R. (2005). Mechanical harvesting and quality of ´marroni´ chestnut. *Acta Hortic. 682, 1193-1198. DOI: 10.17660/ActaHortic.2005.682.158*

Monarca, D., Cecchini, M., Colantoni, A., Menghini, G., Moscetti, R. and Massantini, R. (2014a). The evolution of the chestnut harvesting technique. *Acta Hortic. 1043, 219-225. DOI: 10.17660/ActaHortic.2014.1043.29*

Monarca, D., Moscetti, R., Carletti, L., Cecchini, M., Colantoni, A., Stella, E., Menghini, C., Speranza, S., Massantini, R., Contini, M. and Manzo, A. (2014b). Quality maintenance and storability of chestnuts manually and mechanically harvested. *Acta Hortic. 1043, 145-152. DOI: 10.17660/ActaHortic.2014.1043.19*